battery charger

reliable, yet inexpensive

Charging NiCd batteries does not necessarily require a complex design. The charger described in this article shows that a reliable unit with built-in timer can be constructed for a relatively small outlay.

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INTRODUCTION

Over the years many techniques have been developed for fast, accurate and reliable charging of NiCd batteries. One of the best of these is still the 14-hour method at one tenth of the battery capacity. The present design contains a adjustable current source and a timer which, after normal charging has taken place for 14 hours, switches the charger to trickle charging. Since the current source is adjustable, the charger may be used with a wide variety of NiCd batteries.

DESIGN

The circuit of the charger is shown in **Figure 1**. The peak value of the input alternating voltage must be equal to the requisite charging voltage. This alternating voltage is rectified by bridge B_1, smoothed by capacitor C_9 and applied to regulator IC_5. When this voltage is present, diode D_4 lights.

The alternating voltage is also applied to the clock input of IC_1 via resistor R_1. This means that IC_1 is controlled at a frequency of 50 Hz. A signal at a frequency of $50/2^7$ is output at pin 4 (Q_6) and applied to pin 14 (CLK) of IC_2, where it is divided by 10. This signal is output at pin 7 ((Q_3) and applied to the clock input, pin 10, of IC_4.

The signal is divided by 2^{12} in IC_4, resulting in output Q_{11} (pin 1) of this IC being actuated after 14 hours and 33 minutes (52,428 seconds). Diode D_1 places the output at pin 1 at the clock input, which means that the clock signal cannot alter the counter state.

The battery is charged during this 14 hour plus period by charging circuit which is a discrete design.

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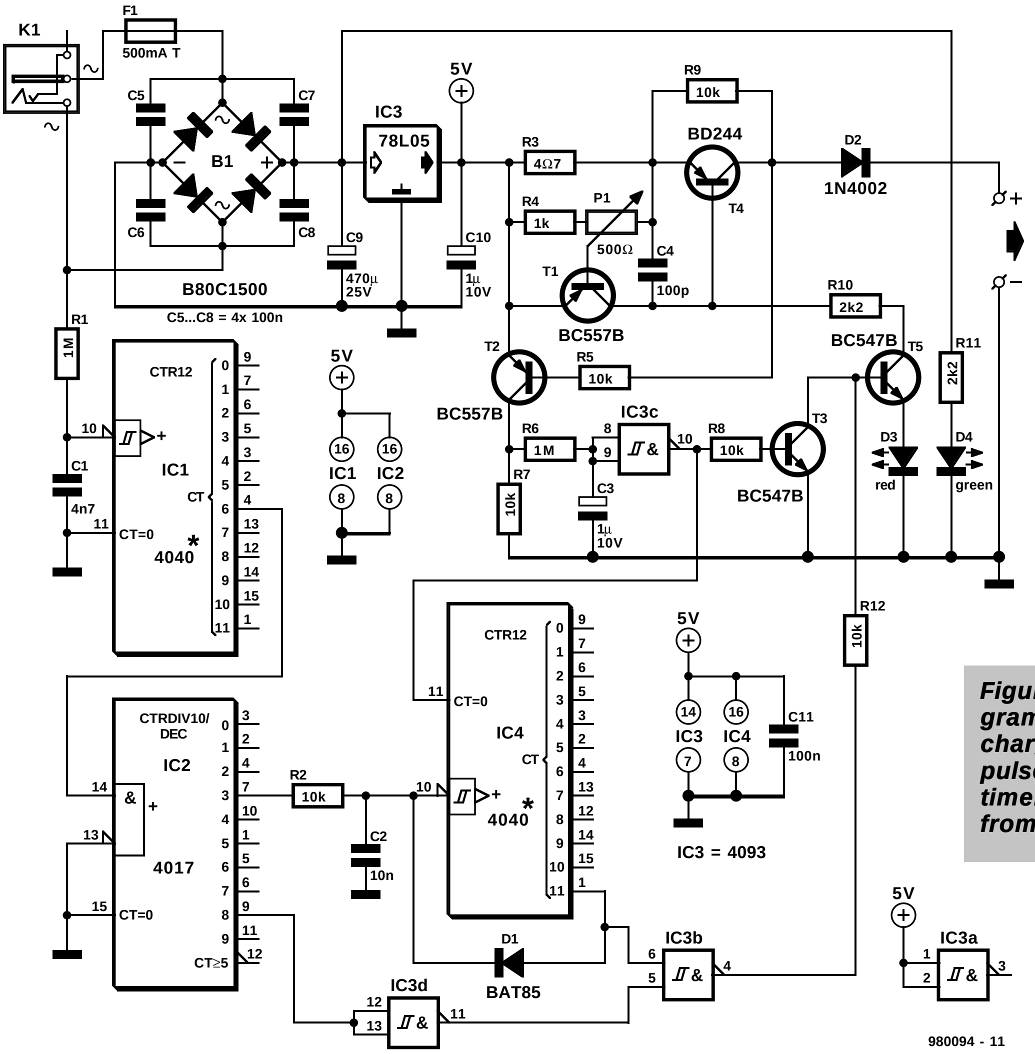

Figure 1. Circuit diagram of the battery charger. The clock pulses controlling the timer are taken direct from the mains voltage.

The adjustable current source is fed with an unregulated voltage. Transistor T_1 is arranged as a variable zener diode. The position of P_1 determines the level of voltage dropped across T_1. This voltage is also applied across resistor R_3. The drop across this resistor, and its value, determine the current flowing from the current source via T_4.

Transistor T_2 functions as a detector. When there is no battery across terminals PC_1 and PC_2, this transistor will be switched off since the potentials at its base and emitter are identical. When a battery is connected across the output terminals, T_2 comes on, whereupon capacitor C_3 is charged via R_6.

After charging has taken place for one second, the output of IC_{3c} goes low. Counter IC_4 is then enabled and transistor T_3 is off. The one second delay time ensures that contact bounce and other interference do not affect the charging process.

Since the output of IC_{3b} is high (output Q_{11} of IC_4 is low after a reset), T_5 comes on. The current source is enabled and charging commences, indicated by the lighting of D_3.

At the termination of the charging process, output Q_{11} of IC_4 goes high, whereupon trickle charging begins. A good level of the trickle-charging current is one tenth of the normal charging current. It is clear that the current source should be modulated to approximate this level. In the present design this is effected by pulse-width modulation.

During normal charging, output Q_{11} of IC_4 is low. Irrespective of the signal at pin 5 of IC_{3b}, the output of IC3b is high. Only when the maximum counter state has been reached does the level at pin 5 determine the level at the output.

Circuit IC_2 is a decade scaler, whose output Q_8 is high for only one tenth of the normal charging period. Circuit IC_{3d} inverts the output so that IC_{3b} ensures that T_5 is on for only one tenth of the normal charging period.

The level of current used for charging is set with P_1. With component values as indicated, the output current may be set between 150 mA (wiper at C_4) and 225 mA (wiper at R_4).

If the unit is used for charging AA batteries, the value of R_3 must be adapted as relevant. With the wiper of P_1 at the centre of its travel, and with $R_3 = 4.7\ \Omega$, the charging current is 180 mA. AA batteries, which have a capacity of 600–700 MaH, need a charging current of 60–70 mA. If the value of R_3 is trebled to 15 Ω, the current is reduced to 60 mA. The setting range is then 50–75 mA.

CONSTRUCTION

The charger is best built on the printed-circuit board shown in **Figure 2**. Construction should not present undue difficulties: all components, including P_1, are to be placed on the board. If the charger is to be used for one type of battery only, P_1 may be a preset type.

Transistor T_4 is located at the edge of the board so that if a heat sink is deemed necessary, this is easily pun into place.

Start by placing the wire links and three PCB pins for mounting P_1, followed by the passive components and the IC sockets. When construction is complete and the work has been checked thoroughly, insert the ICs into the relevant sockets.

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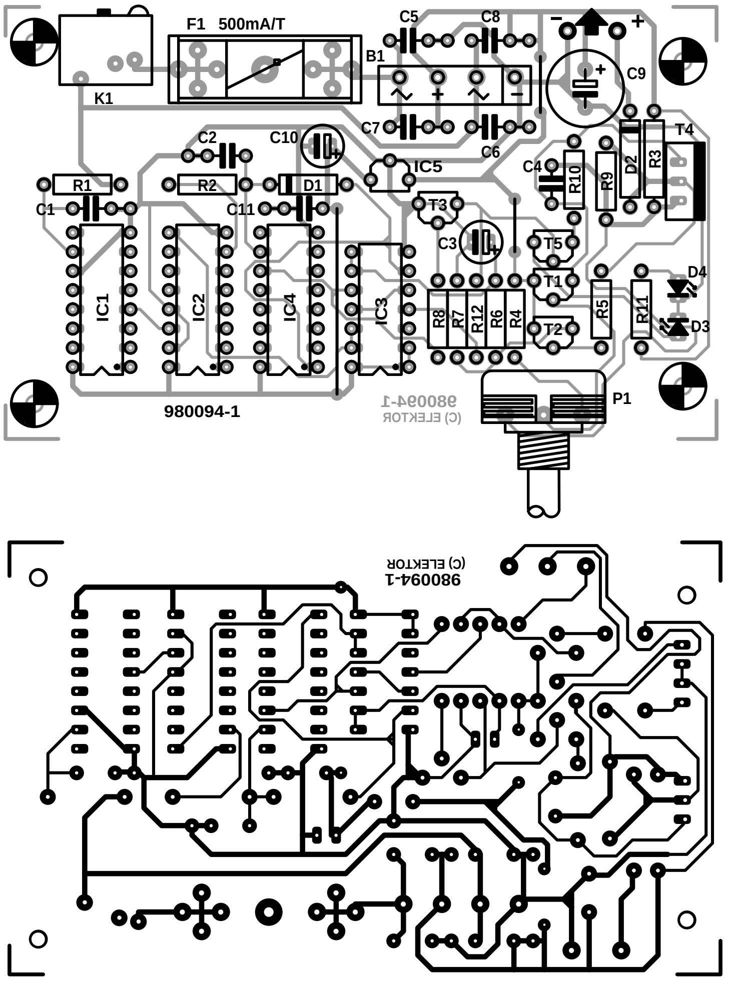

Figure 2. Printed-circuit board for the battery charger.

Parts list

Resistors:
R_1, R_6 = 1 MΩ
R_2, R_5,R_7–R_9, R_{12} = 10 kΩ
R_3 = 4.7 Ω (but see text)
R_4 = 1 kΩ
R_{10}, R_{11} = 2.2 kΩ
P_1 = 500 Ω

Capacitors:
C_1 = 0.0047 µF
C_2 = 0.01 µF
C_3, C_{10} = 1 µF, 10 V, radial
C_4 = 100 pF
C_5–C_8, C_{11} = 0.1 µF
C_9 = 470 µF, 25 V, radial

Semiconductors:
D_1 = BAT85
D_2 = 1N4002
D_3 = LED, 3 mm, red, high efficiency
D_4 = LED, 3 mm, green, high efficiency
T_1, T_2 = BC557B
T_3, T_5 = BC547B
T_4 = BD244

Integrated circuits:
IC_1, IC_4 = 4040
IC_2 = 4017
IC_3 = 4093
IC_5 = 78L05

Miscellaneous:
K_1 = mains adaptor plug for board mounting
B_1 = B80C1500
F_1 = fuse holder with 500 mAT fuse, for board mounting
PCB pins as required
PCB Order No. 980094

FINAL NOTES

Since IC$_1$ is clocked directly by the alternating voltage, it is imperative that this circuit has a Schmitt trigger clock input. Normal logic inputs often cannot handle the leading edge of such a signal correctly and generate additional clock pulses.

The mains adaptor must be an alternating voltage type. Is this difficult or impossible to find, use a direct voltage type and remove the rectifier and smoothing capacitor from it.

The output voltage of the adaptor depends on the type of batteries to be charged. A good choice is an output voltage equal to 1.2–1.45 times the direct voltage for the particular battery. If, for instance, the battery voltage is 7.2 V (as found in electric tools), the alternating voltage output of the adaptor should be 8.7 V, rounded up to 9 V.

If a direct voltage adaptor is used, the timer function cannot be used.

When construction is complete, insert a multimeter set to the 200–500 mA d.c. range, between the charger and the battery to be charged. During charging, adjust P$_1$ until the correct charging current flows. Leave the multimeter in place until charging is complete. If at the end of the normal charging period the current drops a little, a slightly higher supply voltage must be used.

When the adaptor is inserted into the mains outlet, D$_4$ lights. When the battery is connected to the output terminals of the charger, both LEDs light and the charging cycle commences. After a good 14 hours, the red LED goes out, whereupon trickle charging begins. The yellow LED remains on for as long as the charger is connected to the mains. Trickle-charging can go on indefinitely and does not harm the battery.

[980094]

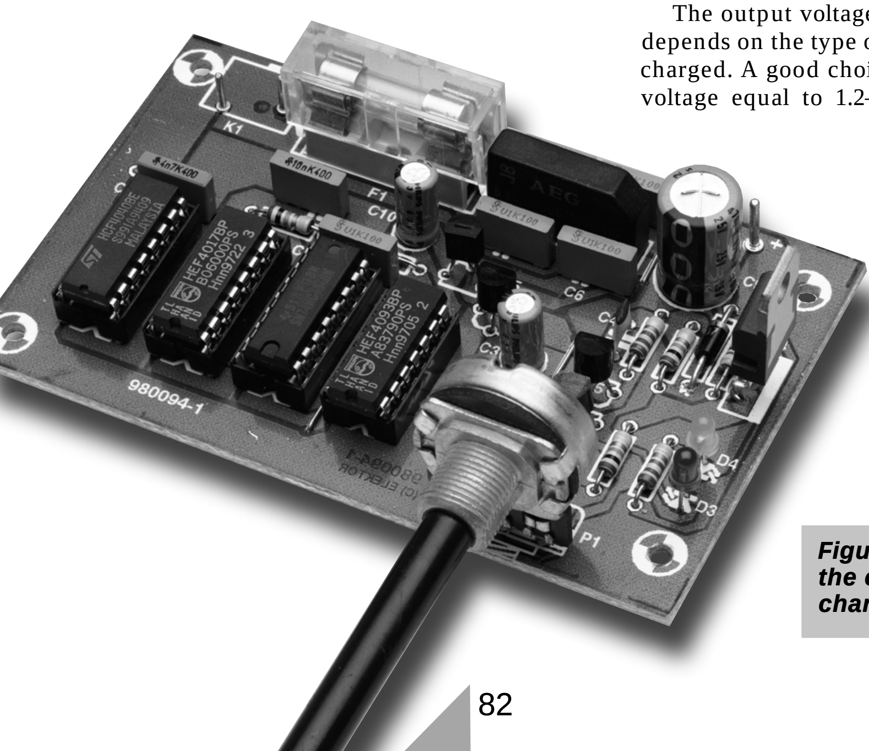

Figure 3. Photograph of the completed prototype charger.